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TITLE: Methods for forming self-planarized dielectric layer for shallow trench isolation

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Abstract Text - ABTX (1):

A method for depositing a trench oxide filling layer (300) on a trenched substrate (224) utilizes the surface sensitivity of dielectric materials such as **O.sub.3 /TEOS**. Such materials have different desposition rates on differently constituted surfaces at different levels on the trenched substrate (224) so that the surface profile of the deposited layer (300) is substantially self-planarized. Depositing the dielectric material on a silicon trench (228) produces a high quality filling layer, and cleaning the trench (228) prior to desposition can increase the quality. After desposition, an oxidizing anneal can be performed to grow a thermal oxide (308) at the trench surfaces and densify the dielectric material. A chemical mechanical polish can be used to remove the excess oxide material above an etch stop layer (226) of the substrate (224) which can be formed of LPCVD nitride or CVD anti-reflective coating.

Brief Summary Text - BSTX (8):

A number of procedures are known for depositing dielectric layers such as the **gap**-fill dielectric 128 for the trench oxide filling layer in the example shown in FIG. 1e. One type of process employs **O.sub.3**

(ozone) and TEOS (tetraethylorthosilicate) for depositing a dielectric film such as silicate glass. Such films deposited are commonly referred to as "**O.sub.3 /TEOS** films". **O.sub.3 /TEOS** processes have a surface sensitivity which increases as the **O.sub.3 /TEOS** ratio increases. Due to the surface sensitivity, the dielectric deposition rate varies in accordance with the properties of the material of the underlying layer.

Brief Summary Text - BSTX (9):

It is known to minimize the surface sensitivity by depositing a surface insensitive barrier layer prior to the **O.sub.3 /TEOS** film deposition. For instance, one known process involves a plasma-enhanced TEOS (PETEOS) deposition, followed by a surface treatment and then a thin cap TEOS layer. This process undesirably requires additional process steps. Another known method is to lower the surface sensitivity by decreasing the **O.sub.3 /TEOS** ratio. However, lowering the **O.sub.3 /TEOS** ratio tends to undesirably result in a more porous dielectric film. This is particularly problematic when the dielectric film is used for isolation purposes. One way to address this concern has been to raise the process temperature to above about 500.degree. C., but raising the process temperature is often undesirable. Alternatively, an additional anneal process after the deposition of the trench oxide filling layer and sandwiching PETEOS layers has been used to densify the trench oxide filling layer. This method, however, suffers from the need to perform an extra step.

Brief Summary Text - BSTX (10):

Instead of minimizing the surface sensitivity, some have

utilized the
deposition rate dependence of **O.sub.3 /TEOS** films to perform **gap** fill for a
trenched silicon substrate wherein the side walls of the trench are covered
with thermal oxide spacers. Using an atmospheric pressure CVD (APCVD) **O.sub.3**
/TEOS deposition and an **ozone** concentration of 5%, it was reported that faster
film growth on the bottom silicon than on the side wall spacers precluded void
formation to achieve void-free **gap** fill. Others have investigated the
feasibility of forming a planarized intermetal dielectric (IMD) by taking
advantage of the surface sensitivity of **O.sub.3 /TEOS** and similar materials
such as O.sub.3 -octamethylcyclotetrasiloiane (OMTC). Researchers have
reported difficulties of controlling the different deposition rates to achieve
planarity. For instance, significant elevations have been observed at the
edges of aluminum metal lines caused by the different deposition rates of the
O.sub.3 /TEOS on a TiN ARC layer on top of the aluminum and the aluminum side
walls. Some of these same researchers have reported more satisfactory
planarization results for depositing SiO.sub.2 layers on an aluminum
interconnect built upon a phosphorus glass (PSG) level using O.sub.3 -OMTC.

Brief Summary Text - BSTX (12):

What is needed are more efficient and economic methods for self-planarized
deposition of a high quality trench oxide filling layer for shallow trench
isolation integration. Improved methods of effectively utilizing the
deposition rate dependence of dielectric materials such as **O.sub.3 /TEOS** films
are also desired.

Brief Summary Text - BSTX (15):

One embodiment of the invention is directed to a method for forming a dielectric layer on a silicon substrate which includes a silicon trench formed between upper portions and having a trench bottom and a trench wall. The substrate is disposed in a substrate processing chamber. The method uses a precursor which provides deposition rate dependence of the dielectric layer on differently constituted surfaces at different levels on the substrate. The differently constituted surfaces at different levels include the trench bottom and a material on the upper portions. The method includes the steps of introducing the precursor, preferably **TEOS,** into the substrate processing chamber and flowing **ozone** into the substrate processing chamber to react with the precursor to deposit a dielectric layer over the substrate. An ozone/precursor ratio between the ozone and the precursor is adjusted to regulate deposition rates of the dielectric layer on the differently constituted surfaces until the dielectric layer develops a substantially planar dielectric surface.

Detailed Description Text - DETX (10):

Compared with the conventional approach illustrated in FIGS. 1a-1d, the method of FIG. 2a can eliminate the process of growing a thermal oxide over the surfaces of the trench, which is conventionally used to repair the plasma damage to the silicon substrate during trench formation. The inventors have found that depositing the surface sensitive dielectric material such as **O.sub.3 /TEOS** directly over a silicon trench significantly improves the quality of the trench fill layer to be formed over prior approaches and that the clean step 222 can further improve film quality, as discussed in more detail below. In